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(54) Magnetic Record Carrier and Method of Making It

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**Canada**

MAGNETIC RECORD CARRIER AND METHOD OF MAKING IT

The invention relates to a magnetic record carrier having a substrate provided with a magnetic coating whose thickness is in the  $\mu\text{m}$  range. The coating consists of a binder, magnetic particles and, optionally, abrasion-resistant particles. The invention also relates to a method of making such record carriers wherein iron oxide particles, the binder and, optionally, abrasion-resistant particles are applied onto the substrate and the binder is cured.

In the field of magnetic record carriers, particularly magnetic disks and magnetic tapes, there is a tendency toward increasingly higher storage densities. High storage densities require a thin magnetic coating having a high coercive field intensity. The read signal has to be high, thus requiring that the magnetic particles have a high magnetization. High magnetization is also required to enable use of small magnetic particles which are needed to obtain a signal with a low noise level.

Small particles of pure iron have the necessary high magnetization, but such particles have so far been used only in connection with magnetic tapes having relatively thick (approximately  $10\mu\text{m}$ ) magnetic layers, since the regular distribution of iron particles within a layer is difficult to achieve. Usually, magnetic coatings are applied by depositing a dispersion of magnetic particles in a fluid matrix onto a substrate. The dispersion of the particles within the fluid matrix is determined by the attractive and repulsive forces between the particles. The repulsive forces determine the dispersion stability and are of an electrostatic nature. The forces are counteracted by the attractive forces which are van der Waal forces, and, in the case of magnetic particles, magnetostatic attraction forces. In the case of iron particles, these magnetostatic attraction forces are so high that dispersion becomes very difficult. Therefore, the dispersion stability could only be achieved in highly viscous systems used for making relatively thick magnetic layers on magnetic tapes. In the production of magnetic disks where the magnetic



coatings are much thinner the mixtures of magnetic particles and binder have a much lower viscosity. The dispersion of iron particles in such mixtures is, therefore, incomplete, or the iron particles agglomerate into clusters which not only have an undesirably high diameter but in which the magnetic moments are partly compensated. Consequently, the magnetization is low and inhomogeneous over the layer. It is pointed out that, owing to the thickness of the magnetic coating in the conventional magnetic tapes, an inhomogeneity caused by non-optimum dispersion of the magnetization of the iron particles or iron particle aggregates can be tolerated. This is another reason why iron particles have been widely used in magnetic tapes but not in the magnetic disks which require a much thinner magnetic coating.

The problem of poor dispersion characteristics is also encountered in connection with  $\text{Fe}_2\text{O}_3$  particles, although to a lesser extent. U.S. Patent 4,280,918 describes a method for improving the dispersion characteristics of  $\text{Fe}_2\text{O}_3$  particles by coating the particles with  $\text{SiO}_2$ . U.S. Patent 4,333,961 also describes a method of applying  $\text{Fe}_2\text{O}_3$  particles coated with  $\text{SiO}_2$  and of uniform size onto a substrate in the form of a mono-layer. As reported by T. Sueyoshi et al. in a lecture entitled "Morphology of Fine Iron Particles" in September 1983 at the M.R.M. Conference in Ferrara, Italy,  $\text{SiO}_2$ -coated  $\text{Fe}_2\text{O}_3$  particles could be reduced to Fe in a hydrogen atmosphere at temperatures between 250 and 350°C. However, it has been equally evident that to disperse the thus produced  $\text{SiO}_2$ -coated iron particles in a binder of low viscosity, or to deposit these as a mono-layer on a substrate is almost as difficult as the same process with uncoated iron particles.

It is the object of the invention to provide a magnetic record carrier with a thin magnetic coating having a high uniform magnetization over the entire layer, and an uncomplicated process for reproducibly making such a magnetic record carrier.

The magnetic record carrier according to the invention has uniformly high magnetization. The magnetic coating has a high packing density of the magnetic particles in view of its low thickness and the necessary high storage density. There is no partial aggregation of the iron particles, and no partial compensation of the magnetic moments of the iron particles.

In an advantageous embodiment of the magnetic record carrier according to the invention the iron particles are dispersed in a binder. The iron particles may be coated with an  $\text{SiO}_2$  layer.

In yet another advantageous embodiment of the magnetic record carrier according to the invention a magnetic coating is formed of a layer of  $\text{SiO}_2$ -coated iron particles deposited on the substrate, and a binder layer thereupon. The binder layer can also contain abrasion-resistant particles. This embodiment has the advantage of providing a substantially thinner magnetic coating.

By first applying the magnetic particles in the form of  $\text{Fe}_2\text{O}_3$  onto the substrate, fixing them in their final location and position, and only then reducing them to iron the method disclosed by the invention elegantly avoids the dispersion problem which had yet been unsolved in connection with iron particles.

In an advantageous embodiment of the method, the iron oxide particles and optionally the abrasion-resistant particles are dispersed in a mixture of the binder with a solvent, the dispersion is deposited on the substrate and cured, and finally or overlappingly reduced in a hydrogen-containing atmosphere. Prior to the dispersion, the iron oxide particles can be coated with  $\text{SiO}_2$  or with a mixture of  $\text{SiO}_2$  and  $\text{Al}_2\text{O}_3$ . Owing to the process selected the binder viscosity is so high upon reduction that there can no longer be any agglomeration and/or re-orientation of the iron particles formed despite the strong forces which the iron particles exert upon each other. Surprisingly, the contact between the iron oxide particles and the hydrogen-containing gas is

apparently not substantially impeded by the binder and the coating. The dispersion of the coated iron oxide particles is even more complete than that of the uncoated iron oxide particles. The additional process step of coating will be used in situations where an extremely homogeneous distribution of magnetic particles of the same diameter in the magnetic coating is of decisive importance.

In another embodiment of the method, the iron oxide particles enveloped with  $\text{SiO}_2$  or  $\text{SiO}_2/\text{Al}_2\text{O}_3$  are applied, by means of an active layer previously deposited on the substrate, onto the substrate in a thin layer, subsequently reduced in a hydrogen-containing atmosphere, and then coated with a mixture comprising the binder, a solvent and, optionally, abrasion-resistant particles. The mixture is then cured. The coated iron oxide particles applied in a thin layer are fixed to the substrate by means of electrostatic forces. Surprisingly, the electrostatic forces are so strong that even the high magnetostatic forces formed upon the reduction of the iron oxide in the iron cannot tear the thus formed coated iron oxide particles from their anchoring and thus modify their position and their orientation relative to each other.

In the following, the invention will be described with reference to the drawings. The drawings show the following:

Figs. 1 to 3                      schematic cross-sectional views  
of three embodiments of the magnetic  
record carrier as disclosed by the  
invention.

The magnetic record carriers described are magnetic disks and magnetic tapes. Quite generally, these magnetic record carriers have a structure composed of a substrate and a magnetic coating thereupon. Substrates can be rigid or flexible. Rigid substrates are usually employed for magnetic disks, but there also exist magnetic disks with flexible substrates, such as the so-called floppy disks. Magnetic tapes obviously all use flexible substrates. Conventional

rigid substrates consist of aluminum, aluminum alloys such as aluminum magnesium, or silicon. All these materials are heat-resistant. Flexible substrate materials are of an organic nature. They may comprise, for example, polyesters. A frequently used example is marketed by Du Pont under the trademark Mylar. If a magnetic record carrier with a flexible substrate is to be made in accordance with the present invention, the substrate has to be heat-resistant. Polyester is not heat resistant. In such a case, polyimide would be a suitable substrate material. The magnetic layer on the substrate has a thickness between 0.1 and 0.8  $\mu\text{m}$ , preferably 0.3  $\mu\text{m}$ . With layer thicknesses within the above range the necessary high storage densities can be realized. The magnetic coating consists of a binder, the magnetic particles and, optionally, abrasion-resistant particles. The term binder refers to the matrix containing the magnetic particles in the finished magnetic coating, or covering the magnetic particles in the finished magnetic coating as well as the material which is converted into this matrix in the course of the production of the magnetic coating. A typical binder is a material selected from the group of temperature-stable polymers comprising epoxide phenol resins, polyimide, melamine, polyamide and polypyrrolidine. The magnetic particles consist of iron or of cobalt-doped iron. The particles are acicular and have a length to thickness ratio between 5:1 and 10:1. The length of the iron particles is between 0.08 and 0.8  $\mu\text{m}$ . The optionally existing abrasion-resistant particles which are added to prevent abrasion upon the sliding of a magnetic head on the magnetic layer are preferably of spherical shape, and have a diameter less than or equal to the thickness of the magnetic layer. They preferably consist of a hard ceramic material such as aluminum oxide, silicon carbide or silicon nitride.

With reference to Figs. 1 to 3, three different embodiments of the magnetic record carrier will be described.

Fig. 1 depicts, in a schematic cross-section, a magnetic record carrier such as a magnetic disk with a rigid substrate which differs from the known magnetic disks only in that the

magnetic particles consist of iron rather than  $\text{Fe}_2\text{O}_3$ , and the iron particles are smaller than the iron oxide particles in the known magnetic disks. In the embodiment of Fig. 1, a magnetic coating is applied onto a substrate 1. The coating consists of a binder 2, magnetic iron particles 3 dispersed therein, and, optionally, abrasion-resistant particles (not shown), preferably of aluminum oxide. The thickness of the magnetic coating and the size of the iron particles is in the range of the above given values.

Fig. 2 is a sectional view of another embodiment of the record carrier. The embodiment of Fig. 2 differs from that of Fig. 1 in that the magnetic iron particles 3 are coated with a layer consisting of silicon dioxide or a mixture of silicon dioxide/aluminum oxide. The coating is between 2 and 50 nm thick, preferably between 8 and 20 nm. In comparison with the embodiment of Fig. 1, the coating increases the reliability of practically all iron particles existing individually in a uniform distribution in the magnetic layer. In the embodiments of Figs. 1 and 2, the surface density of the magnetic particles is approximately  $10^9$  to  $10^{10}$  particles/cm<sup>2</sup>, depending on the pigment volume concentration and the particle size.

The embodiment of Fig. 3 clearly differs in its structure from those depicted in Figs. 1 and 2. A substantially blanket mono-layer consisting of iron particles 3 with a coating 4 is deposited onto substrate 1. The thickness of the mono-layer is between approximately 0.02 and approximately 0.05  $\mu\text{m}$ . A layer of binder 2 is applied onto the layer of magnetic particles. Binder 2 can also contain abrasion-resistant particles (not shown). In order to improve the adhesion of the iron particles to the substrate, a thin active layer 5 is provided between substrate 1 and the layer of iron oxide particles 3. Layer 5 can consist of a mixture of an epoxide resin and a polyamide, or it can be formed by a mono-layer of a cationic polyelectrolyte produced out of an aqueous solution of polyethyleneimine or polyacrylamide. Layers 5 and the layers consisting of iron particles 3 and

binder 2 have a combined thickness between approximately 0.05 and 0.3  $\mu\text{m}$ . Coating 4 of iron particles 3 can be composed in the same manner and of precisely the same thickness as in the case of the coated iron particles in the embodiment of Fig. 2. In the embodiment of Fig. 3 the surface density of the particles is again approximately  $10^9$  to  $10^{10}$  particles/cm<sup>2</sup>.

The method as disclosed by the invention uses many of the same process steps - as are used in the production of known magnetic disks. Thus, according to the invention, the magnetic particles and the binder which optionally includes abrasion-resistant particles are applied onto the substrate. The binder used has a low-molecular state, and is mixed with a solvent or a solvent mixture. The mixture has a low viscosity so that it can be applied onto the substrate by means of spinning. After the deposition of the binder-containing mixture the solvent is evaporated and the binder is cured or polymerized. In a last process step there usually follows the polishing of the then present magnetic coating. The method as disclosed by the invention essentially differs from the known method of making magnetic disks in that the particles applied onto the substrate in the form of iron oxide are reduced to iron, directly after application in those cases where the magnetic particles are deposited individually, i.e. without the binder, and after the binder curing where the magnetic particles are applied dispersed in the binder.

In the following, the production of the embodiments of the magnetic record carrier as disclosed by the invention as represented in Figs. 1 to 3 will be described, with the record carrier produced being assumed to be a magnetic disk with a rigid substrate in each instance. The manufacturing processes described however can be applied without modification to the production of magnetic disks with a flexible substrate. In making magnetic tapes, only the process for depositing the binder-containing mixture has to be modified.



In the embodiment according to Fig. 1, iron oxide particles are dispersed together with the binder, as .g. an epoxide resin preparation, usually abrasion-resistant particles, e.g. of  $\text{Al}_2\text{O}_3$  and optionally admixtures like a cross-linking agent in a solvent or solvent mixture. Such dispersions are produced in agitators, ball or bead mills. The dispersion preferably consists (in percent by weight) of approximately 60 % of a solvent mixture (mixture consisting of xylol, ethylamylketone and isophorone), and approximately 40 % of a solid substance mixture (approximately 50 % binder, approximately 49 %  $\text{Fe}_2\text{O}_3$  and approximately 1 %  $\text{Al}_2\text{O}_3$ ). The finished dispersion is used to coat the magnetic disk substrate preferably consisting of an aluminum magnesium alloy, and subsequently the desired layer thickness (preferably approximately  $0.3\mu\text{m}$ ) is reached by means of spinning-off. During the coating process, a permanent magnet is preferably arranged under the substrate, and the dispersion is applied in the location with the gap of the magnet beneath, i.e. in the place with the highest field intensity. The magnetic particles are aligned in rotation direction in parallel to the substrate surface. There follows the curing of the applied magnetic coating by heating for approximately 2 hours to a temperature in the order of  $200^\circ\text{C}$ . Subsequently, at a temperature between  $250$  and  $400^\circ\text{C}$ , preferably  $325^\circ\text{C}$ , the iron oxide particles are reduced to pure iron in a hydrogen atmosphere. Reduction can also be effected in an atmosphere containing nitrogen and hydrogen, but the reduction times would then have to be extended, and the temperatures used would have to be raised. The binder employed has to be so resistant from a chemical and thermal point of view that it does not decompose under reduction conditions. This applies to the epoxide resin mentioned as an example. Other binders satisfying this condition are polyimide, melamine, polyamide and polypyrrolidine. The modifications of the magnetic characteristics caused by the reduction are listed in the first column of the table below. The last process step is the polishing of the surface of the magnetic coating. Finally, the magnetic coating is equipped with a lubricant, possibly after a cleaning step.

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TABLE

Percent modifications of the magnetic characteristics (starting and end values of one respective sample in brackets 5\*) through the reduction of the  $\text{Fe}_2\text{O}_3$

	magnetic particles dispersed in the binder		layer of magnetic particles 4*	
	reduction after curing of the binder	reduction prior to the curing of the binder		
	particles coated 1*	particles uncoated 2*	particles uncoated 3*	
saturation moment	$\leq 50 \%$ ( $5.7 \cdot 10^{-3} \rightarrow 8.4 \cdot 10^{-3} \text{ emu}$ )	$\leq 50 \%$ ( $10 \cdot 10^{-3} \rightarrow 15 \cdot 10^{-3} \text{ emu}$ )	unchanged	$\leq 40 \%$ ( $1.1 \cdot 10^{-3} \rightarrow 1.5 \cdot 10^{-3} \text{ emu/cm}^2$ )
remanence	$\leq 48 \%$ ( $3 \cdot 10^{-3} \rightarrow 4.4 \cdot 10^{-3} \text{ emu}$ )	$\leq 40 \%$ ( $8.2 \cdot 10^{-3} \rightarrow 11.5 \cdot 10^{-3} \text{ emu}$ )	"	"
coercive-field intensity	$\leq 95 \%$ (490 $\rightarrow$ 957 Oe)	$\leq 150 \%$ (284 $\rightarrow$ 770 Oe)	100 % (270 $\rightarrow$ 560 Oe)	$\leq 150 \%$ (350 $\rightarrow$ 880 Oe)
	1* results of 4 samples	2* results of 6 samples	3* results of 2 samples	4* results of 7 samples

5\* The emu (electromagnetic unit) values given are merely to demonstrate the order of the three parameters. The values given in the first two columns were measured in connection with samples which all had a surface of approximately 1 cm<sup>2</sup> but were of different layer thicknesses and magnetic particle densities. Furthermore, unlike the conditions during the application of the particles for making the other samples, there was no permanent magnet under the substrate during the application of the dispersion containing coated particles and the binder. For that reason, the given emu values cannot be compared.

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To make the embodiment of Fig. 2, the iron oxide particles are first coated with an  $\text{SiO}_2$  or  $\text{SiO}_2/\text{Al}_2\text{O}_3$  layer. An  $\text{SiO}_2/\text{Al}_2\text{O}_3$  coating is preferably made in that the iron oxide particles are dispersed in water and subsequently processed, with predetermined  $p_H$  values in the basic range being maintained and at increased temperatures first with a silicate and subsequently with an aluminum salt solution.  $\text{SiO}_2/\text{Al}_2\text{O}_3$  layers can be produced on iron oxide particles as follows:

45 g  $\text{Fe}_2\text{O}_3$  particles of a uniform length, preferably between 0.1 and 1.0  $\mu\text{m}$ , which are commercially available, are heated with 300 ml distilled water, and stirred, at approximately 20,000 rpm to 90°C. The  $p_H$  is adjusted by the drop-by-drop admixture of an NaOH solution at 10.0. After the admixture of 20 ml of a 40 % sodium silicate solution the  $p_H$  is rapidly lowered to 9.0 by the drop-by-drop admixture of hydrochloric acid. Stirring is continued for one hour, with the temperature of 90°C being maintained and deviation from the  $p_H$  of  $9.0 \pm 0.1$  being corrected by the admixture of NaOH or HCl, respectively. After the expiration of the reaction time, 20 ml of a 50 % aluminum sulfate solution are admixed very rapidly, and the  $p_H$  is immediately reduced to 8.0 by means of hydrochloric acid admixture. After another 60 minutes reaction time, with stirring being continued and a reaction temperature between 93 and 95°C being maintained, the process is terminated. The thus coated iron oxide particles are filtered, thoroughly rinsed with distilled water, dried at 150°C, and finally pulverized.

For making an iron oxide particle coating consisting of colloidal silicon dioxide an advantageous method consists in that an aqueous suspension of the iron oxide particles and an aqueous suspension of colloidal silicon dioxide particles is made. In the first mentioned suspension, the  $p_H$  is fixed at a level where the iron oxide particles receive a positive electrostatic charge. The suspension containing silicon dioxide particles is set to the same  $p_H$ , with the effect that the silicon dioxide particles adopt a negative electrostatic charge. If both suspensions are joined together,

the iron oxide particles are covered with the silicon dioxide particles with which they irreversibly bond. This method is known from US-Patent 4 280 918. The individual process steps are as follows:

$\gamma$ - $\text{Fe}_2\text{O}_3$  particles of the desired granular size are mixed with a suitable acid, e.g. hydrochloric acid, and the mixture is stirred for a time. The iron oxide particles have a tendency to form aggregates. Stirring facilitates the separation of the aggregates into individual particles as the bridges between the particles are dissolved. After stirring, the  $p_H$  of the mixture is adjusted to a suitable value in order to generate a positive electrostatic charge on the magnetic particles. Iron oxide particles have a pronounced positive electrostatic charge in the  $p_H$  range between 3 and 6. For that reason the  $p_H$  of the mixture is adjusted to a value within this range. Furthermore, a mixture of colloidal silicon dioxide particles and an acid is made. The  $p_H$  is adjusted to approximately the same value as in the mixture containing the magnetic particles. Colloidal silicon dioxide particles have a considerable negative electrostatic charge in the  $p_H$  range between 3 and 6. The two mixtures are cleaned and subsequently stirred, preferably with an additional ultrasonic energization to support the reaction. The colloidal silicon dioxide particles with their negative electrostatic charge are attracted by the iron oxide particles which have a positive charge. Preferably, the mixture contains more colloidal silicon dioxide particles than necessary in order to completely cover the iron oxide particles. This surplus is advantageous because it supplies a sufficient amount of silicon dioxide particles for rapidly coating an iron oxide particle separated from other iron oxide particles before it can again be attracted by other iron oxide particles. After coating, the iron oxide particles are irreversibly connected with the adsorbed mono-layer of protective colloidal particles, and they are thus sufficiently distanced from each other so that their mutual magnetic attraction and thus their tendency to form aggregates has been considerably reduced.

Exemplified embodiment demonstrating the method with yet further detail:

5 g  $\gamma$  iron oxide powder was mixed with 50 ml of a 5 % HCl, and exposed for 3 minutes to an ultrasonic treatment with a power of 400 watts. Subsequently, 12 ml of concentrated HCl were admixed, and the mixture was stirred for 40 minutes. The iron oxide particles were then rinsed with water until a  $p_H$  of 3.5 had been reached. Furthermore, a suspension containing 5 g colloidal silicon dioxide particles was mixed with a cationic ion exchange resin, and stirred, until a  $p_H$  of 3.5 was reached. As an alternative it would have been possible to implement the  $p_H$  change by the admixture of dilute sulfuric acid or hydrochloric acid. The ion exchange resin was removed by means of filtration, and the suspension of the colloidal silicon dioxide particles was admixed to the iron oxide particle suspension. The mixture was then exposed for 10 minutes to ultrasonic treatment with a power of 400 watts. A silicon dioxide particle surplus and other non-magnetic material was then removed by means of magnetic sedimentation. Subsequently, the  $p_H$  of the mixture was increased to a value in the vicinity of 9.5, first by the admixture of water and various decanting operations, and then by the admixture of a suitable base, as e.g. sodium hydroxide. Finally, the coated iron oxide particles were filtered and dried.

The coated iron oxide particles are used for making a magnetic disk as represented in Fig. 2. The process applied is exactly the same as for making the magnetic disk of Fig. 1, with the only difference that for making the embodiment of Fig. 1 the iron oxide particles are not coated. The alterations of the magnetic properties thus caused in reduction are listed in the second column of the table.

For realizing the embodiment depicted in Fig. 3 of the magnetic record carrier as disclosed by the invention, coated iron oxide particles that had been made as described above are applied onto the substrate as a mono-layer. The process of deposition is described in U.S. Patent 4,333,961.

The substrate has to be prepared for receiving the coated iron oxide particles. This preparation is effected by applying an active layer onto the substrate. The process of deposition is based on an electrostatic interaction between ionic particles with a surface of an opposite ionic charge, in an aqueous environment. This requires a charged surface layer or active layer. There exist several ways of making such an active layer.

In accordance with one of these ways the active layer is generated by dissolving an epoxide resin or a polyamide in cyclohexanone and spinning the solution onto the substrate. An epoxide resin known as Epon 1004 and marketed under that trademark by Shell Corporation, can be used. A polyamide known as Versamid 100 marketed under that trademark by Henkel Corporation may also be used. The deposited layer is approximately 50 nm thick. The layer is tempered at approximately 150°C for about 30 minutes in order to partly polymerize it, or to reduce the percentage of the low-molecular fraction, respectively without all  $\text{NH}_2$ - and  $\text{NH}$ -groups being eliminated. The  $\text{NH}_2$ - and  $\text{NH}$ -groups are the source of the positive surface charge in an aqueous environment.

Alternatively, the active layer can be produced by applying a mono-layer of a cationic polyelectrolyte out of an aqueous solution such as polyethyleneimine or polyacrylamide onto the substrate. Subsequently, the surplus is rinsed off, and the forming of the active layer is thus finished. The active layer can also be made by applying methods like ultraviolet grafting or plasma polymerization. To deposit the magnetic particles on the disk substrate, after the generation of the active layer, it is preferable to place the substrate onto a slowly rotating coating unit which is made to rotate with a speed between 0.1 and 5 rpm over the gap of a permanent magnet. The iron oxide particles coated with silicon dioxide or  $\text{SiO}_2/\text{Al}_2\text{O}_3$  are injected or pumped in the form of an aqueous dispersion onto the substrate over the area of the highest magnetic field intensity of the magnet.

The magnetic particles are aligned in the direction of rotation in parallel to the substrate surface. The magnetic particles are oriented while they still exist in their dispersed form prior to the actual coating process. The negatively charged particles bond with the positively charged active layer on the substrate owing to electrostatic interaction. As soon as the particles are placed on the surface they remain there. Owing to the electrostatic repulsion between the magnetic particles, any magnetic particle surplus is easily rinsed off. The coated substrate is then dried by spinning, and heated to approximately 150°C for about 15 minutes. The process described can be modified so that the substrate is first coated with a thin water film, and the process is then continued as specified above. The deposited layer has a high pigment volume concentration, and good magnetic orientation. The magnetic particles do not show any agglomeration tendency.

In the next process step, the coated iron oxide particle layer is exposed to a hydrogen atmosphere at an increased temperature. The layer is preferably exposed for one hour at a temperature of 350°C to a hydrogen stream of 30 cm<sup>3</sup> per minute. After reduction, the modifications to the magnetic characteristics caused by the reduction were measured for seven samples. The measured values are listed in the last column of the table. A microscopic examination of the layer revealed that the reduction had in no way altered the position of the particles in the layer.

Onto the structure existing after reduction a dispersion is applied which, apart from the absence of the magnetic particles, is like the dispersion used for the production of the magnetic record carriers shown in Figs. 1 and 2. Subsequently, the layer containing the binder is cured, at a temperature of approximately 250°C for approximately 1 hour. The conditions (viscosity of the dispersion, rotational speed) are selected in such a way that the material deposited on the substrate after curing is between approximately 0.05 and 0.3  $\mu$ m, preferably about 0.1  $\mu$ m thick. The structure now

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available is subsequently polished. Owing to the application of the binder-containing layer the magnetic coating now has excellent mechanical stability and abrasion-resistance. The magnetic characteristics are not altered by such application.

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The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A magnetic record carrier having a substrate, a magnetic coating on said substrate, said coating having thickness in the  $\mu\text{m}$  range and consisting of a binder and magnetic particles, wherein said magnetic particles are substantially non-aggregated iron particles.
2. A magnetic record carrier as defined in claim 1 wherein said binder includes abrasion-resistant particles.
3. A magnetic record carrier as claimed in claim 1, wherein said iron particles are coated with a layer selected from  $\text{SiO}_2$  and  $\text{SiO}_2/\text{Al}_2\text{O}_3$ .
4. A magnetic record carrier as claimed in claim 2, wherein said iron particles are coated with a layer selected from  $\text{SiO}_2$  and  $\text{SiO}_2/\text{Al}_2\text{O}_3$ .
5. A magnetic record carrier as claimed in any one of claims 1, 2 or 3, wherein said iron particles are homogeneously distributed in said binder.
6. A magnetic record carrier as claimed in claim 3, wherein said coated iron particles form a layer which is electrostatically bonded to an active layer covering said substrate, said active layer exhibits positive surface charges in an aqueous medium prior to the application of said iron particles, and wherein said iron particle layer is covered with said binder.

7. A magnetic record carrier as claimed in claim 4, wherein said coated iron particles form a layer which is electrostatically bonded to an active layer covering said substrate, said active layer exhibits positive surface charges in an aqueous medium prior to the application of said iron particles, and wherein said iron particle layer is covered with said binder.
8. A magnetic record carrier as claimed in any one of claims 1, 2 or 3, wherein said binder is selected from a group of temperature-stable polymers, including polyimide, melamine, polyamide, polypyrrolidine and epoxide resin.
9. A method of making a magnetic disk comprising the steps of  
  
depositing a mixture of iron oxide particles and a binder on a substrate,  
  
curing the binder deposited on the substrate,  
  
reducing the iron oxide particles on the substrate to iron, and  
  
polishing the resultant cured and reduced layer on the substrate.
10. A method as claimed in claim 9, further including the step of coating said iron oxide particles with a layer of  $\text{SiO}_2$  or  $\text{SiO}_2/\text{Al}_2\text{O}_3$  prior to depositing said particles on said substrate.
11. A method as claimed in claim 9 wherein said binder includes abrasion-resistant particles.

12. A method as claimed in claim 10 wherein said binder includes abrasion-resistant particles.
13. Method as claimed in any one of claims 9, 10 or 11, wherein said iron oxide particles are dispersed in a mixture of said binder and a solvent, or a solvent mixture, and the resulting dispersion is deposited onto said substrate and cured, and said iron oxide particles are reduced in a hydrogen-containing atmosphere.
14. A method as claimed in claim 10 or 12 further including the step of covering said substrate with a thin, active layer exhibiting positive charges prior to depositing said iron oxide particles on said substrate, said iron oxide particles being spun onto said thin layer in an aqueous dispersion, and any non-adhering iron oxide particles being rinsed off with water, said reducing being performed in a hydrogen-containing atmosphere, after which follows the depositing with a dispersion of said binder.
15. A method as claimed in any one of claims 9, 10 or 11 further including the step of applying a field from a permanent magnet beneath the rotating substrate during the deposition of said iron oxide particles, said iron oxide particles being deposited in the area which is over the gap of the permanent magnet.
16. A method as claimed in any one of claims 9, 10 or 11 wherein said reducing step takes place at a temperature between 250 and 400°C in a hydrogen stream between 15 and 35 ml per minute, for 1 to 1.5 hours.



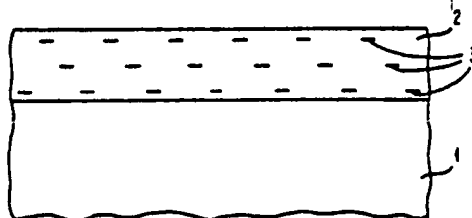


FIG. 1

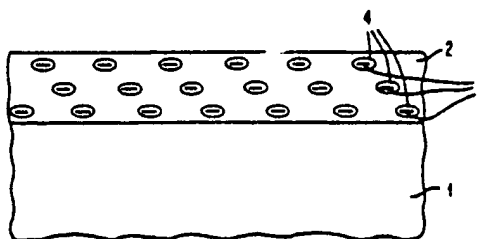


FIG. 2

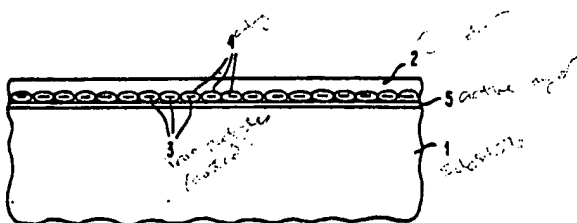


FIG. 3

*[Signature]*

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